This document contains Part 2 (pp.115–130) of Chapter 4 of the National Coastal Condition Report III.

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National Coastal Condition Report III

Chapter 4: Southeast Coast Coastal Condition

Part 2 of 2

December 2008

Trends of Coastal Monitoring Data—Southeast Coast Region

Temporal Change in Ecological Condition

EMAP-Estuaries conducted annual surveys of estuarine condition in the Carolinian Province from 1994 to 1997, the results of which were reported in the NCCR I (U.S. EPA, 2001c). In 2000, EMAP-NCA initiated annual surveys of coastal condition in the Southeast Coast region, which includes the Carolinian Province and part of the West Indian Province. The assessment of 2000 data was reported in the NCCR II, and data from 2001 and 2002 are assessed in this current report (NCCR III). These seven years of monitoring data from Southeast Coast coastal waters provide an ideal opportunity to investigate temporal changes in ecological condition indicators. The data can be analyzed to answer two basic types of trend questions based on assessments of ecological indicators in Southeast Coast coastal waters: what is the interannual variability in the percentages of area rated good, fair, or poor, and is there a significant change in the percentage of area rated poor from the mid-1990s to the present?

This comparison was conducted using data for the same indicators, collected using similar methods over the same geographic area. The ecological parameters that can be compared between these time periods include water clarity, dissolved oxygen concentrations, sediment toxicity, sediment contaminants, sediment TOC, and benthic condition. Data supporting these parameters were collected using similar protocols and QA/QC methods. Fish tissue contaminants data were also collected by both surveys during both time periods; however, these data were excluded from this trend analysis because the sample preparation methods were not comparable. The available water quality data on chlorophyll *a* and nutrients from the EMAP-NCA survey (2000) were also excluded because these parameters were not evaluated during the EMAP-Estuaries surveys (1994–1997). In addition, the spatial extent of the EMAP-NCA Southeast Coast regional data was reduced to match that of the Carolinian Province surveyed during the EMAP-Estuaries study. The Carolinian Province extends from the Virginia–North Carolina state border to the Indian River Lagoon on the east coast of Florida.

Both programs (EMAP-Estuaries and EMAP-NCA) implemented probability-based surveys that support estimations of the percentage of coastal area rated in good, fair, or poor condition based on the indices and component indicators assessed. Standard errors for these estimates were calculated according to methods listed on the EMAP Aquatic Resource Monitoring Web site (http://www.epa.gov/nheerl/arm). The reference values and guidelines listed in Chapter 1 were used to determine good, fair, or poor condition for each index and component indicator from both time periods.

None of the indices or component indicators assessed showed any significant linear trends over time in the percent of coastal area rated poor (Figures 4-8 through 4-13); however, when the time periods were compared, some differences were observed (Figure 4-14). The percentage of coastal area rated poor for sediment toxicity was significantly greater for the time period from 1994 to 1997 than for 2000 to 2002 ($z = 3.67$; $p < 0.05$).

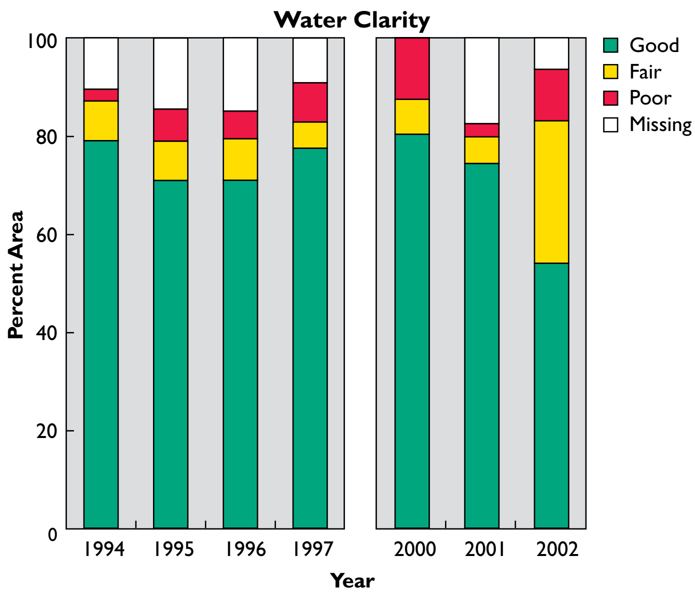


Figure 4-8. Percent area of Southeast Coast coastal waters in good, fair, poor, or missing categories for water clarity measured over two time periods, 1994–1997 and 2000–2002 (U.S. EPA/NCA).

Similarly, significantly greater percentage of the coastal area was rated poor for sediment contaminants from 1994 to 1997 than from 2000 to 2002 ($z = 2.028$; $p < 0.05$). In addition, the percentage of coastal area rated poor was greater (although not significantly) for the time period 1994–1997 than for 2000–2002 for all of the other indicators measured, with the exception of sediment TOC. Sediment TOC increased slightly from 5.5% to 7.2%, although this increase was not significant ($p < 0.05$). It should be noted that sediment toxicity samples were not collected in 1996, and these data were considered to be missing for 100% of the coastal area in 1996.

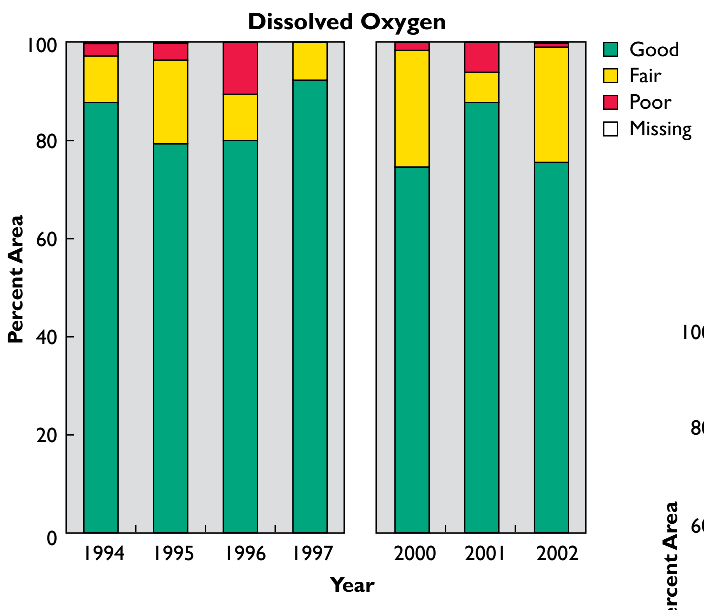


Figure 4-9. Percent area of Southeast Coast coastal waters in good, fair, poor, or missing categories for bottom-water dissolved oxygen concentrations measured over two time periods, 1994–1997 and 2000–2002 (U.S. EPA/NCA).

Porty spider crabs are bottom-dwelling scavengers found in estuarine waters from Nova Scotia to the Gulf of Mexico (courtesy of Andrew David, NMFS, and Lance Horn, University of North Carolina at Wilmington).

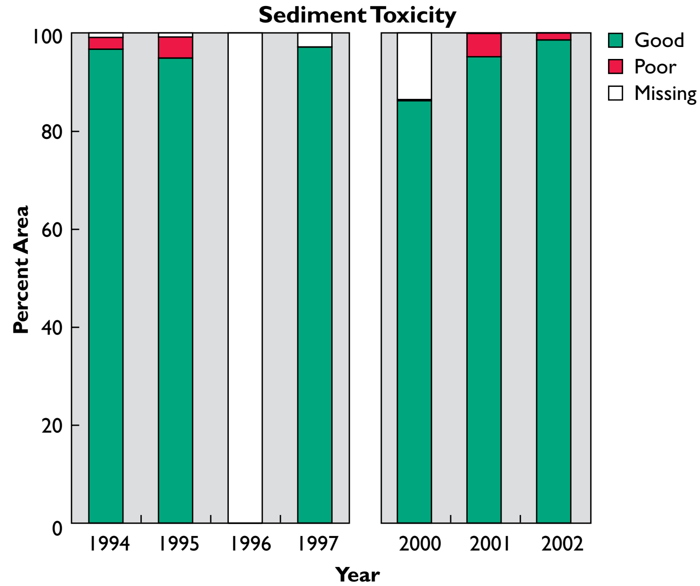


Figure 4-10. Percent area of Southeast Coast coastal waters in good, poor, or missing categories for sediment toxicity measured over two time periods, 1994–1997 and 2000–2002. No data were collected in 1996 (U.S. EPA/NCA).

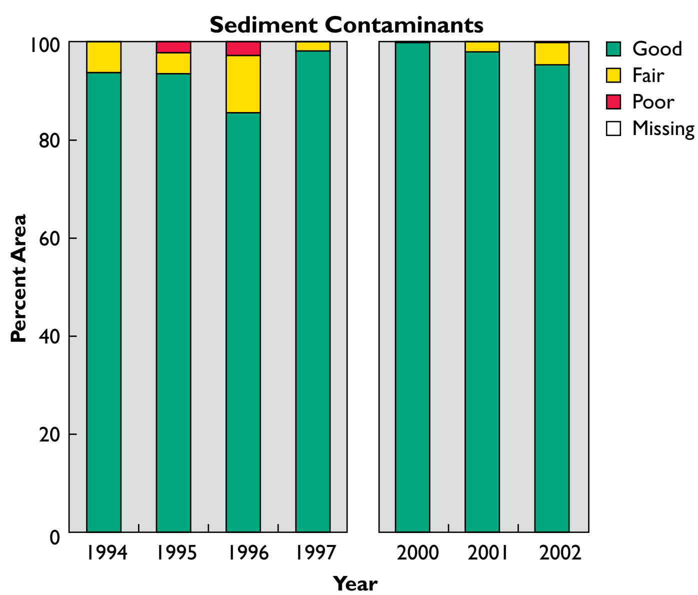


Figure 4-11. Percent area of Southeast Coast coastal waters in good, fair, poor, or missing categories for sediment contaminants measured over two time periods, 1994–1997 and 2000–2002 (U.S. EPA/NCA).

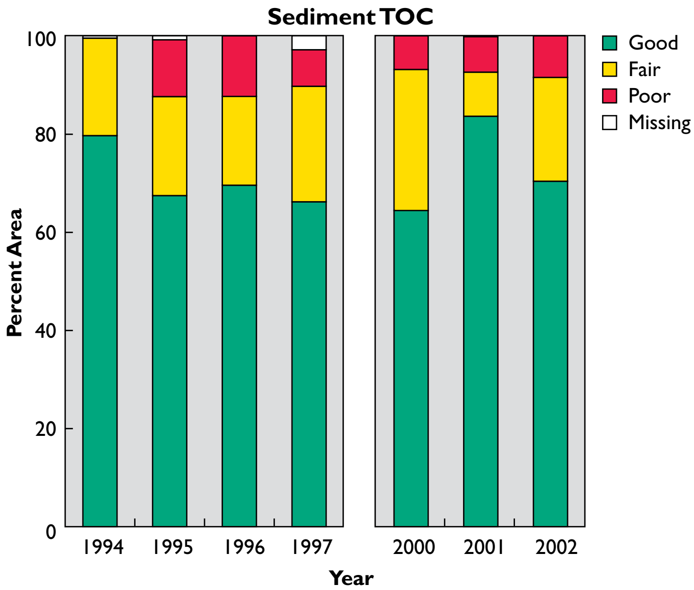


Figure 4-12. Percent area of Southeast Coast coastal waters in good, fair, poor, or missing categories for sediment TOC measured over two time periods, 1994–1997 and 2000–2002 (U.S. EPA/NCA).

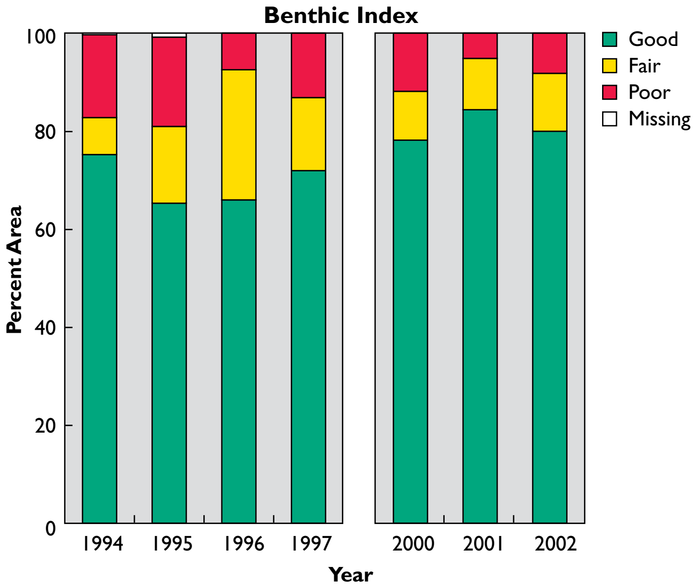


Figure 4-13. Percent area of Southeast Coast coastal waters in good, fair, poor, or missing categories for the benthic index measured over two time periods, 1994–1997 and 2000–2002 (U.S. EPA/NCA).

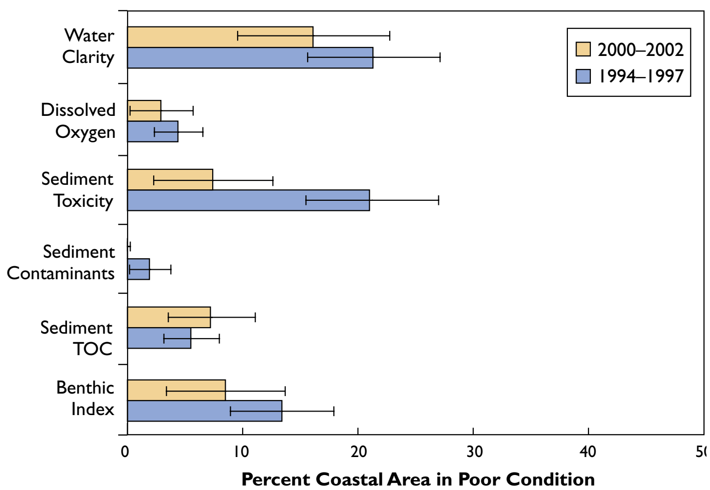
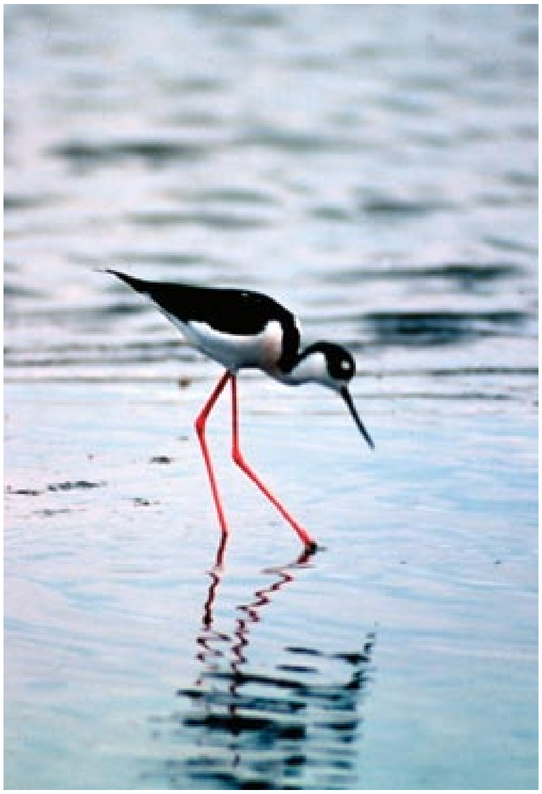


Figure 4-14. Comparison of percent area of Southeast Coast coastal waters rated poor for ecological indicators between two time periods, 1994–1997 and 2000–2002. Error bars are 95% confidence intervals (U.S. EPA/NCA).



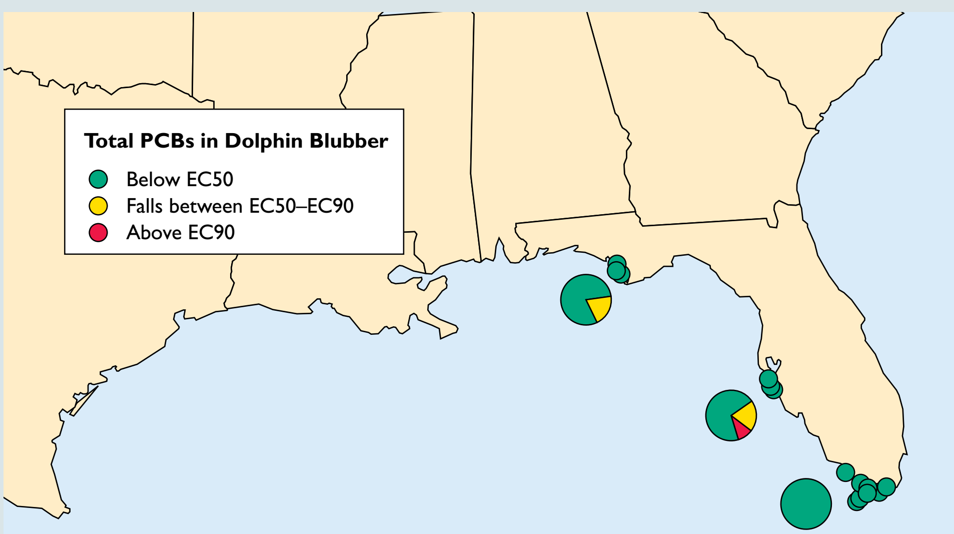
Black-necked stilts are found along edges of shallow waters, such as the ACE Basin NERR (courtesy of NOAA).

Bottlenose Dolphin Tissue Contaminants

Bottlenose dolphins are apex predators in estuarine and nearshore waters along the Atlantic coast from Long Island, NY, south to Florida and along the coast of the Gulf of Mexico. In many estuaries, bottlenose dolphins are year-round residents, showing a high degree of site fidelity. As such, dolphins can be good indicators of ecosystem contamination, particularly for very persistent pollutants such as PCBs. Total PCB concentrations were measured in blubber from live dolphins sampled along the Atlantic coast between 2000 and 2004 (Hansen et al., 2003). In the Gulf of Mexico, total PCB concentrations were measured in blubber from live dolphins in Sarasota Bay, FL, in 2000–2001 (Wells et al., 2005) and Florida Bay in 2002 (NOAA, 2003a), as well as from stranded bottlenose dolphins near St. Joseph Bay, FL, during an unusual mortality event (UME) in 2004 (NIST, 2004). Researchers have also examined concentrations of other organic compounds, including polyfluoroalkyl compounds (PFAs), in dolphin blubber and blood.

Female dolphins transfer a majority of their PCB contaminant load to their offspring during lactation, and it is difficult to interpret PCB concentrations from the blubber of a female dolphin without knowledge of the dolphin's reproductive history. For this reason, this analysis used total PCB concentrations analyzed in samples collected from male dolphins. The measured total PCB concentrations were compared to estimated risk values proposed by Schwacke et al. (2002). These risk values correspond with PCB concentrations that are estimated to cause reproductive failure (e.g., stillbirths, calf mortality) in dolphins. Measured total PCB levels of 33 µg/g lipid are considered to be the effective concentration required to induce 50% reproductive failure (EC50). Levels of 51.2 µg/g lipid are considered to be the effective concentration required to induce 90% reproductive failure (EC90).

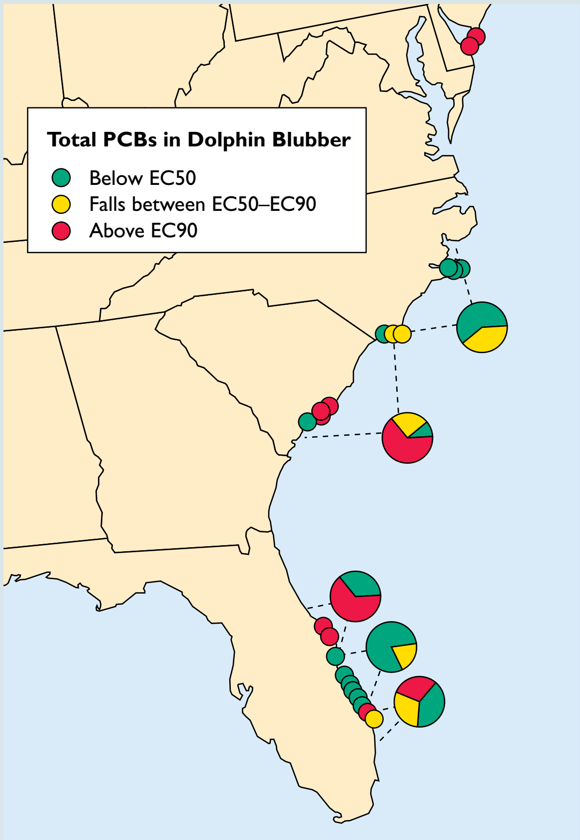
The results of these studies along the Gulf and Atlantic coasts are shown in the maps. For sites where many dolphins were sampled (≥ 5), data are summarized as a pie chart showing the proportion of the samples falling into each category. All of the dolphins sampled from Florida Bay and most of the UME dolphins from St. Joseph Bay showed total PCB concentrations below the EC50. In Sarasota Bay, 27% of dolphins had total PCB concentrations in their tissues above the EC50, but



Total PCB concentrations measured from the blubber of male dolphins sampled along the U.S. Gulf of Mexico coast, 2000–2004 (Wells et al., 2005; NOAA, 2003a; NIST, 2004).

only 9% measured concentrations above the EC90. In the Atlantic Coast estuaries around Charleston, SC, and in Florida's Mosquito Lagoon and the northern portion of the Indian River Lagoon, more than 60% of the male dolphins sampled showed total PCB values above the EC90. In addition, all tissue samples from the New Jersey coast measured PCB concentrations above the EC90, but only a few samples (n=4) were available. Dolphins sampled from estuaries and coastal regions of North Carolina and within the middle portion of the Indian River Lagoon fared better, with no individuals showing PCB concentrations above the EC90. Concentrations of total PCBs were higher than concentrations of other measured organic compounds at all of the sampled sites, and results of analyses of inorganic contaminants (e.g., metals) in dolphin tissues are not yet available.

Recently, scientists have identified other emerging chemical contaminants of concern, including PFAs, in the environment. PFA concentrations were measured in dolphin blood during capture-and-release studies in Sarasota Bay, FL, and at three Atlantic Coast sites (Houde et al., 2005). Differences in PFA levels were observed between sampling sites, but little is known about the potential health effects of these compounds in dolphins. The mean summed PFA concentration (900 ppb wet weight) measured in dolphins from Sarasota, FL, was similar to that measured in dolphins from Indian River Lagoon, FL (800 ppb wet weight) and less than that measured in dolphins from Charleston, SC (1800 ppb wet weight), and Delaware Bay, DE (1600 ppb wet weight). Additional research is needed to determine whether these levels of PFAs put dolphins at increased health risk.



Total PCB concentrations measured from the blubber of live male dolphins sampled along the U.S. Atlantic Coast between 2000 and 2004. Data sources: Charleston, SC; Indian River Lagoon, FL; and Beaufort, NC, data from Hansen et al. (2003) and from the NOAA Center for Coastal Environmental Health and Biomolecular Research (unpublished) and Harbor Branch Oceanographic Institute (unpublished); data for other sites from National Institute for Standards and Technology (unpublished) and NMFS (unpublished).

Large Marine Ecosystem Fisheries—Southeast U.S. Continental Shelf LME

The Southeast U.S. Continental Shelf LME extends from Cape Hatteras, NC, to the Straits of Florida (Figure 4-15) and is characterized by its temperate climate. This LME is considered to be moderately productive based on primary production (phytoplankton) estimates, and upwelling along the Gulf Stream front and intrusions from the Gulf Stream can cause short-lived plankton blooms. The Southeast U.S. Continental LME is distinguished by a very high percentage of commercially important crustacean catches. The valuable coastal shrimp fishery accounts for 10% of the total tonnage landed from this LME. Reef fishes, sciaenid species, menhaden, and mackerel are also important fisheries. The fisheries in this LME are managed by NMFS and the South Atlantic Fishery Management Council (SAFMC) (NOAA, 2007g).

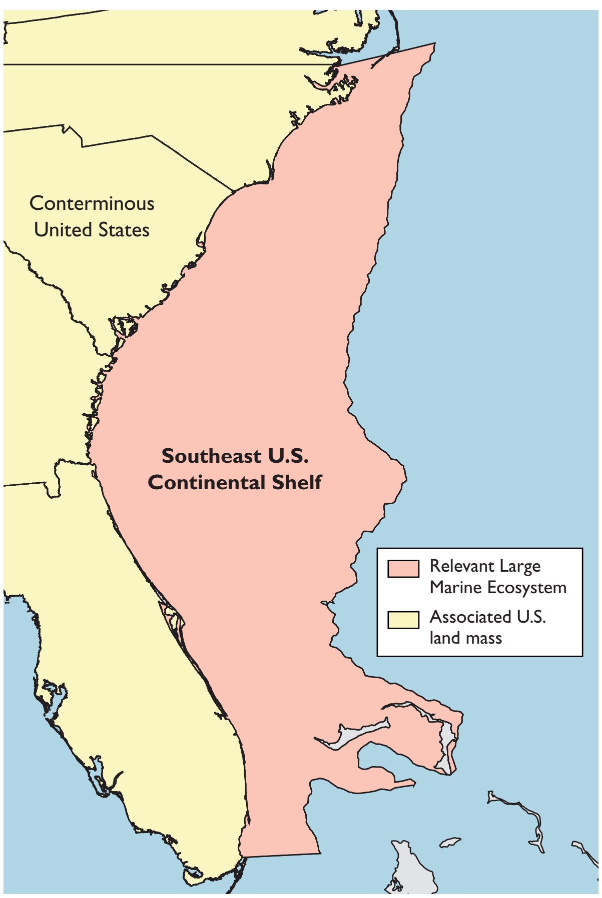


Figure 4-15. Southeast U.S. Continental Shelf LME (NOAA, 2007g).

The portion of the Atlantic coast of the United States that borders the Southeast U.S. Continental Shelf LME includes diverse habitats ranging in salinity, flora, and fauna. The coastal area includes freshwater and estuarine habitats, nearshore and barrier islands, and oceanic communities. Watersheds that drain the lower Appalachian Mountains, Piedmont, and Coastal Plains empty into the ecosystem along the coastlines of North Carolina, South Carolina, Georgia, and eastern Florida. The flow of fresh water mixes along the coast with prevailing oceanic waters to create diverse wetlands, marsh, and mangrove habitats that transition gradually from freshwater to brackish-water to saltwater areas. From an ecosystem perspective, this thin fringe of estuaries is dynamic, varying constantly with tidal fluctuations and levels of runoff, and serves as important habitat for invertebrates, fish, reptiles, waterfowl, mammals, and a diverse array of plants. These estuaries also act as a natural filter to remove pollutants and trap sediments from upland regions. The Southeast U.S. Continental Shelf LME coastal area supports diverse aquatic organisms and complex food webs in an irreplaceable nursery system. This system promotes the recruitment (addition of a new generation of young fish) and development of juvenile fish and invertebrate species that are important to recreational, commercial, and ecological interests.

Reef Fish Resources

Reef fish are generally found in reef or reef-like, hard-bottom habitats. Dominant reef fish species in the Southeast U.S. Continental Shelf LME include red, yellowtail, vermilion, and mutton snappers; red and gag grouper; black sea bass; and greater amberjack. In the Southeast U.S. Continental Shelf LME, the fishery for reef fishes has historically been conducted within waters that are less than 600-feet deep or within the area that approximates the outer edge of the continental slope. Reef fish fisheries are extremely diverse, have many users (commercial and recreational), and vary greatly by location and species (NMFS, In press).

Combined commercial and recreational landings of reef fish from the Southeast U.S. Continental Shelf LME have fluctuated since 1976, showing a slightly decreasing trend over time (Figure 4-16).

The recent average yield of reef fish species (2001–2003) was 6,407 t. Meanwhile, fishing pressure has increased significantly, with many stocks currently considered overfished. Regulations pertaining to the management of reef fish include prohibitions on the use of fish traps (except pots for black sea bass) and trawl gear, minimum-size limits, permitting systems for commercial fishermen, bag limits, quotas, seasonal closures, Special Management Zones, and the establishment of Marine Protected Areas prohibiting the harvest of any species. Reef fish are part of a complex, diverse multi-species ecosystem. The long-term effects of harvesting on reefs are not well understood, requiring cautious management controls of targeted fisheries (NMFS, In press).

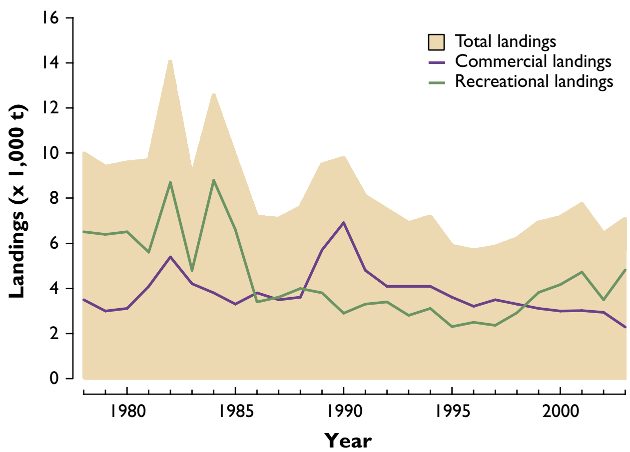


Figure 4-16. Reef fish landings from the Southeast U.S. Continental Shelf LME, 1978–2003, in metric tons (t) (NMFS, In press).

Sciaenids Fisheries

Fish of the family *Sciaenidae* include 22 species in the Southeast U.S. Continental Shelf LME. Some of the more notable members of this family of fish are red drum (*Sciaenops ocellatus*), black drum (*Pogonias cromis*), Atlantic croaker (*Micropogonias undulatus*), weakfish (*Cynoscion regalis*), spotted seatrout (*Cynoscion nebulosus*), kingfish (*Menticirrhus spp.*), and spot (*Leiostomus xanthurus*). Sciaenids have constituted an important fishery resource along the Atlantic coast since the late 1800s. Currently, these fish species support substantial harvests for both commercial and recreational fisheries and are captured with almost every type of gear used to fish the coastal waters of the Atlantic Ocean (NMFS, In press).

Of the sciaenid species for which an FMP has been developed, red drum is currently classified as overfished; weakfish is classified as recovered; and there is not enough information available to adequately determine the stock status of the remaining species. Commercial landings of red drum increased rapidly in the mid-1980s when market demand grew suddenly for blackened redfish, a gourmet seafood dish. In addition, large numbers of sciaenids (e.g., small Atlantic croaker, spot, and seatrout) are caught and killed as an incidental catch in Southeast U.S. Continental Shelf LME shrimp fisheries. Because much of this bycatch consists of juveniles, fishing mortality from incidental catches may slow the recovery of overfished stocks. Shrimp management regulations require the use of bycatch-reduction devices, which shrimpers in the Southeast U.S. Continental Shelf LME currently use. Use of these devices has contributed to the rebound of some overfished stocks, such as weakfish. Recent declines in the spotted seatrout abundance index in Southeast U.S. Continental Shelf LME waters have been attributed to increased coastal development leading to habitat loss and heavy fishing pressure. Regulations for sciaenid fishes in the Atlantic Ocean vary by state and range from no restrictions to complicated restrictions based on fish size and daily bag limits. The populations of several species of sciaenids, most notably Atlantic croaker and spotted seatrout, appear to be closely linked to environmental conditions, resulting in large annual population fluctuations (NMFS, In press).

Menhaden Fishery

The geographical range of the Atlantic menhaden extends from West Palm Beach, FL, to Nova Scotia, Canada. Menhaden are prey for many fish, marine mammals, and sea birds and form an important component of both the Southeast and Northeast U.S. Continental Shelf LMEs. Menhaden landings from these LMEs are reported by the Southeast Fisheries Science Center.

Landings and participation in the menhaden fishery (23 factories and more than 100 vessels on the Atlantic coast) increased rapidly after World War II, reaching peak harvests between 1953 and 1962, with record landings of 712,100 t in 1956

(Figure 4-17). Sharp declines in landings thereafter resulted in plant closings and vessel reductions. Stock rebuilding occurred during the 1970s and 1980s, and menhaden landings climbed to 418,600 t in 1983. During the late 1980s and 1990s, the fishery consolidated, primarily because of low product prices. In 2003, only 2 reduction plants and 12 vessels remained in operation on the Atlantic coast. The Virginia portion of Chesapeake Bay is currently the center of the modern menhaden fishery. In addition, an active baitfish fishery along the coast operates primarily in Virginia and New Jersey and harvests about 15% to 20% of the medhaden landed by the industrial fishery. The resource is almost fully utilized, with a maximum sustainable yield of 408,999 t per year and a recent average yield of 228,000 t annually for the 2001–2003 time period (NMFS, In press).

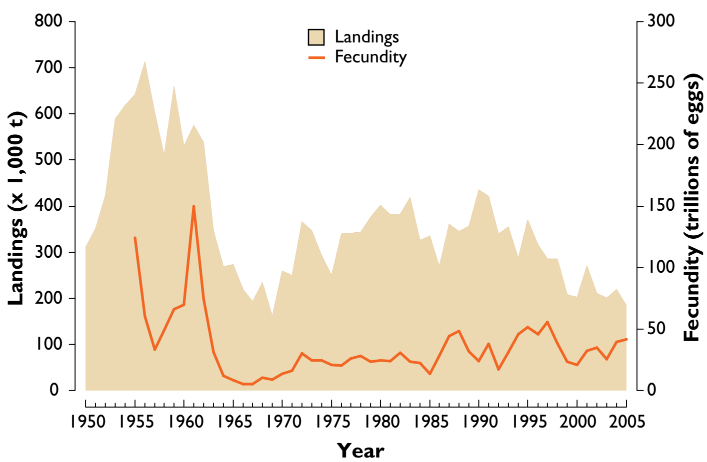


Figure 4-17. Landings in metric tons (t) and fecundity (potential reproductive capacity) in trillions of eggs of Atlantic menhaden, 1950–2002 (NMFS, In press).

Declining fishing effort in recent years has likely reduced the rate at which older menhaden are removed from the population, allowing time for the recruitment of new generations of young fish. In the past, relatively low survival to the age of 1 year has been a major concern for the Atlantic menhaden stock. The last dominant cohort (the generation of new fish from the same year that are the most prevalent in the population) occurred in 1988, and subsequent cohorts (generations of fish from the same year) have generally been poor to mediocre. Recruitment appears to be hindered largely by environmental conditions (centered

Menhaden are most commonly used for fertilizer and pet food (courtesy of Bob Williams, NOAA).

in the Chesapeake Bay area), rather than by a lack of spawning stock. If recruitment continues to decline, erosion of the spawning stock may follow. Currently, several studies are examining the role of menhaden in the food web, with the goal of managing forage and predator fish species at a multi-species level (NMFS, In press).

Mackerel Fisheries

King and Spanish mackerel are two coastal pelagic (dwelling in the water column) fish species inhabiting the Southeast U.S. Continental Shelf LME. Coastal pelagics are fast swimmers that school and feed voraciously, grow rapidly, mature early, and spawn over many months. U.S. and Mexican commercial fishermen have harvested Spanish mackerel since the 1850s and king mackerel since the 1880s.

The total catch of Southeast U.S. Continental Shelf LME king mackerel averaged 3,345 t per fishing year from 1981 to 2001, with a maximum of 4,365 t in 1985 and a minimum of 2,570 t in 1999. The total catch was 2,748 t in 2001, and the recent average yield was 2,665 t for the 2000–2001 and 2002–2003 time periods. In 2003, the maximum sustainable yield was estimated at 2,680 t for king mackerel stock in this LME. On average, landings of king mackerel are larger for the recreational sector (66%) than for the commercial sector (34%), and landings have been below the total allowable catch limits since 1986. According to the 1998 and 2003 stock assessments, the stock is not overfished, nor is overfishing occurring, although it is near its estimated long-term potential yield. Currently, there are restrictions for the commercial fishing industry sector, including annual total allocated catch restrictions, minimum-size restrictions, gear restrictions, and catch trip limits. For the recreational sector, restrictions include bag limits, minimum-size limits, and annual quota allocations. Current issues affecting the Southeast U.S. Continental Shelf LME king mackerel stock concern the bycatch of juveniles in the shrimp trawl fishery and the allocation of landings within the mixing zone between Southeast U.S. Continental and Gulf of Mexico LME stocks (NMFS, In press).

The total catch of Southeast U.S. Continental Shelf LME Spanish mackerel averaged 2,307 t per fishing year from 1984 to 2001, with a maximum of 3,188 t in 1991 and a minimum of 1,406 t in 1995. In 2001, the total catch was 2,305 t, and the recent average yield was 2,716 t for the 2000–2001 to 2002–2003 time periods. For this LME, Spanish mackerel landings have also been below the total allowable catch limits, at least since 1991. The 1998 and 2003 stock assessments concluded that the Spanish mackerel stock in this LME was not overfished and that overfishing was not occurring, although current estimates indicate that the stock is exploited at its near-optimum, long-term yield (which is based on the maximum sustainable yield modified to account for economic, social, or ecological factors). At present, management restrictions for the commercial fishery of the Southeast U.S. Continental Shelf LME Spanish mackerel include minimum-size restrictions, gear restrictions, trip limits, and quota allocations. A major recreational fishery exists for Spanish mackerel throughout its range, and the percentage of landings by recreational anglers has increased since the mid-1990s to about 50% of all landings of the Southeast U.S. Continental Shelf LME stock. For the recreational fishery, there are minimum-size restrictions, bag limits, and charter-vessel permit requirements. Current issues affecting this stock include bycatch from the shrimp trawl fishery and the allocation of landings within the mixing zone between Southeast U.S. Continental Shelf and Gulf of Mexico LME stocks (NMFS, In press).

Shrimp Fisheries

The trend in commercial landings of the major shrimp species over the past 40 years has remained stable, while fishing pressure has increased. The shrimp stocks in the Southeast U.S. Continental Shelf LME appear to be more affected by environmental conditions than by fishing pressure. Both pink and white shrimp populations are affected by cold weather. The young of these species over-winter in estuaries and can potentially “freeze out” if water temperatures drop to lethal levels. The lower temperatures do not affect brown and rock shrimp populations because juveniles of these species are not found in the estuaries during cold seasons. Annual variations in white and pink shrimp populations due to fluctuating environmental conditions are a natural phenomenon that will likely continue to occur despite management activities; however, the recovery of the affected stocks can be mediated by management practices (NMFS, In press).

The current shrimp FMP (SAFMC, 2005) uses the mean total shrimp landings as a reasonable proxy for maximum sustainable yield. The harvest of shrimp in the Southeast U.S. Continental Shelf LME has fluctuated around stable levels for several years. This trend in landings has been maintained even though an increase in vessels has been observed; therefore, it seems these stocks are fully exploited. The recent average yield of brown, pink, rock, and white shrimp from the Southeast U.S. Continental Shelf LME was 10,984 t for the 2001–2003 time period (NMFS, In press).

NMFS catch statistics indicate that commercial shrimp species are being harvested at maximum levels; therefore, an increase in fishing effort is not likely to lead to an increase in catch. Although fishing mortality may affect future shrimp stocks in years experiencing harsh environmental conditions, the greatest threat to shrimp populations is the loss or destruction of habitat. Pollution or physical alteration of the salt marsh and inshore seagrass habitats results in changes to habitats that are critical nursery areas for juvenile shrimp (NMFS, In press).

Highlight

South Carolina Oyster Restoration and Enhancement (SCORE) Program

Natural South Carolina intertidal reef adjacent to fringing salt marsh (courtesy of South Carolina DNR).

Oysters are important because they not only provide a resource to harvest and enjoy, but also provide a number of ecosystem services. These services include filtering vast quantities of water, serving as an important habitat for numerous commercially and ecologically important estuarine species, and protecting marsh shorelines from erosion. Populations of the native eastern oyster, *Crassostrea virginica*, are declining throughout its range extending from Canada to South America, with populations in some areas, such as the Chesapeake Bay, at less than 1% of the historic abundance. In South Carolina, there are adequate breeding stocks of oysters, but recruitment (settling of oyster larvae out of the water column) is limited by the amount of substrate available for attachment (South Carolina DNR, 2007b).

The South Carolina DNR is responsible for managing the state's oyster resource habitats. In order to increase oyster reef habitat at a minimum cost to taxpayers, South Carolina DNR has initiated the South Carolina Oyster Restoration and Enhancement Program (SCORE) to increase the amount of substrate available for oyster recruitment in the state's waters. Community-based restoration and related monitoring are key components of SCORE. The program restores and enhances oyster resources and habitat by planting recycled oyster shells into the intertidal environment. Volunteers from across the state are helping to strategically place recycled oyster shells, thereby creating new oyster shell habitats for natural recruitment in areas with little or no natural oysters or substrate for recruitment (South Carolina DNR, 2007b).

SCORE also serves other uses beneficial to the state agencies and residents. The South Carolina DNR uses SCORE's small oyster shell reefs (hundreds of bushels of shells) to evaluate approaches for the department's larger oyster-planting program, which has involved placing tens of thousands of bushels of recycled shells onto acres of formerly barren, intertidal habitat on public grounds. In addition, the community-based aspect of SCORE helps to educate the public about the significant ecological and economic role of oysters in South Carolina. It is important for the community to understand that oysters are much more than a seafood treat and to learn about oysters' biology and the human activities that can influence their well-being (South Carolina DNR, 2007b).

Appropriate management of oyster resources includes the planting of appropriate shell material (cultch) to provide substrate for larval oyster recruitment onto the permanent substrate where they will reside as adults. The best cultch material is fresh oyster shells, but this material is getting scarce. There is a nationwide shortage of oyster shells to be used as cultch because many oyster shells go to landfills or are used for decorative purposes (tabby walls) or road bed coverage. Some volunteer groups recycle their own shells, but most use shells from the South Carolina DNR's larger Shell Recycling Program, which encourages the public to recycle oyster shells at one of the more than 16 designated recycling centers located along the South Carolina coast. The recycled shells generated in this fashion are used for restoration and enhancement of shellfish resources, reducing the costs of these activities (South Carolina DNR, 2007a). Less than 10% of the oysters harvested in South Carolina are returned to the South Carolina DNR for restoration projects (South Carolina DNR, 2007b). Additional shells may be recovered if volunteer groups recycle shells as a service project or if the shell material from restaurants, caterers, and resorts were recovered before going to a landfill.

Volunteers collect oyster shells before bagging them for use in oyster habitat restoration projects (courtesy of South Carolina DNR).

South Carolina DNR's largest completed reef at Mt. Pleasant, SC (courtesy of South Carolina DNR).

Since May 2001, SCORE has used more than 13,000 bags (over 275 tons) of oyster shells to complete over 120 reefs at 29 reef sites along the South Carolina coast. As these shell-bag reefs begin to recruit new oysters and attract other inhabitants of the estuary, they are also being used as living classrooms and South Carolina DNR research platforms. Volunteer support is critical to monitoring the new reefs throughout the year to increase understanding of how best to restore oyster habitats. Support to date has come from state and federal agencies, foundations, and volunteers, more than 2,000 of whom have been involved in one or more aspects of the program (South Carolina DNR, 2007b).

By working together, community members and South Carolina DNR biologists are restoring oyster populations while also enhancing habitat for fish, shellfish, mammals, and birds; improving water quality and the clarity of estuarine areas; and informing and educating children, industry, and the general public. More information on SCORE and other oyster-related links are available on SCORE's Web site at http://score.dnr.sc.gov. Information about the Shell Recycling Program is available at the Web page http://saltwaterfishing.sc.gov/oyster.html.

Assessment and Advisory Data

Fish Consumption Advisories

Ten fish consumption advisories were active in the coastal waters of the Southeast Coast region in 2003 (Figure 4-18). All four coastal states of this region—North Carolina, South Carolina, Georgia, and Florida—had statewide advisories covering all coastal waters to warn citizens against consuming large quantities of king mackerel because of potential mercury contamination. Florida and South Carolina also had statewide advisories for other species of fish. Because of these statewide advisories, 100% of the total coastline miles of the Southeast Coast region were under advisory in 2003. Most (91%) fish consumption advisories for the Southeast Coast region were issued, at least in part, because of mercury contamination (Figure 4-19), with separate advisories issued for only two other pollutants: PCBs and dioxins. All of the fish advisories for PCBs covered parts of Georgia, and the one fish advisory for dioxin was in North Carolina's Albemarle-Pamlico Estuarine System (U.S. EPA, 2004b).

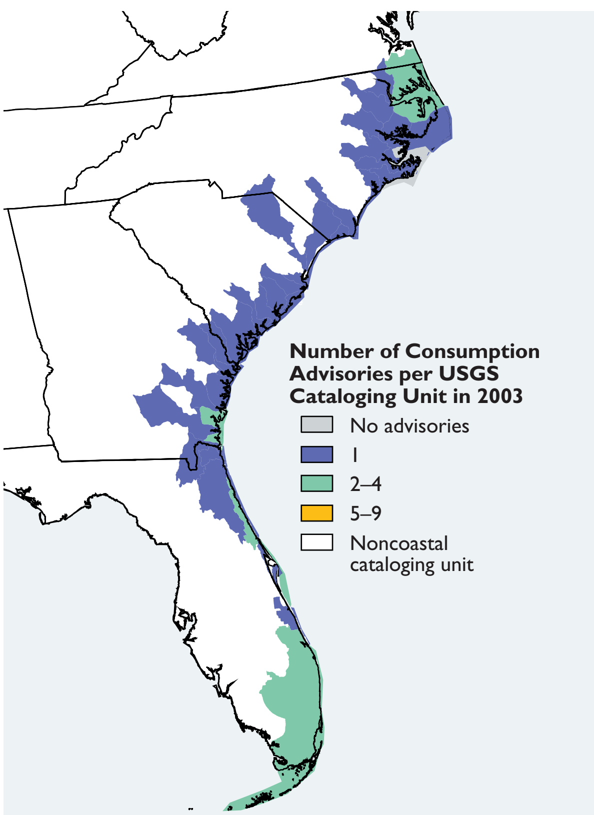


Figure 4-18. The number of fish consumption advisories in effect in 2003 for the Southeast Coast coastal waters (U.S. EPA, 2004b).

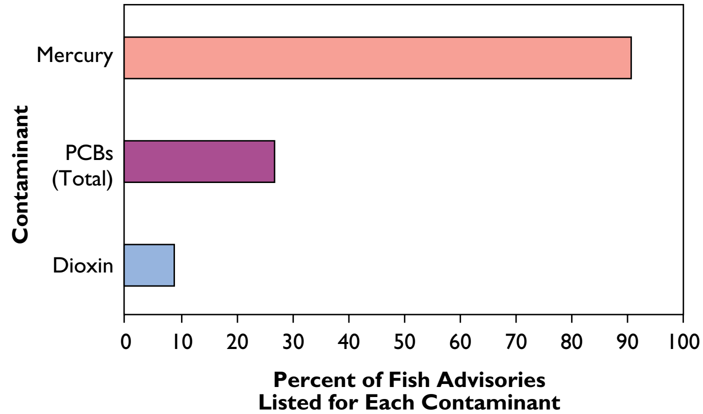


Figure 4-19. Pollutants responsible for fish consumption advisories in Southeast Coast coastal waters. An advisory can be issued for more than one contaminant, so percentages may add up to more than 100 (U.S. EPA, 2004b).

Species and/or groups under fish consumption advisory in 2003 for at least some part of the coastal waters of the Southeast Coast region	
Almaco jack	King mackerel
Atlantic croaker	Ladyfish
Black drum	Largemouth bass
Blackfin tuna	Little tunny
Blue crab	Mussels
Bluefish	Oysters
Bowfin	Red drum
Carp	Shark
Catfish	Silver perch
Clams	Snowy grouper
Cobia	Spotted seatrout
Crevalle jack	Swordfish
Flounder	Tilefish
Greater amberjack	

Source: U.S. EPA, 2004b

Beach Advisories and Closures

Of the 487 Southeast Coast beaches reported to EPA in 2003, only 12% (59 beaches) were closed or under an advisory for any period of time during that year. Table 4-1 presents the number of beaches monitored and the number of beaches under closures or advisories reported for each state. Figure 4-20 presents advisory and closure percentages for each county within each state (U.S. EPA, 2006c).

Table 4-1. Number of Beaches Monitored and With Advisories/Closures in 2003 for Southeast Coast States (U.S. EPA, 2006c)

State	No. of Beaches Monitored	No. of Beaches With Advisories/ Closures	Percentage of Beaches Affected by Advisories/ Closures
North Carolina	222	21	9.5
South Carolina	7	2	28.6
Georgia	37	NR	NR
Florida (East Coast)	226	36	15.9
TOTAL	**492**	**59**	**12.0**

NR = Not Reported.

Most beach advisories and closures were implemented at beaches along the Southeast Coast because of elevated bacteria levels (Figure 4-21). Although stormwater runoff was identified as a source of beach contamination in the Southeast Coast region, unknown sources accounted for 97% of the survey responses (Figure 4-22, U.S. EPA, 2006c).

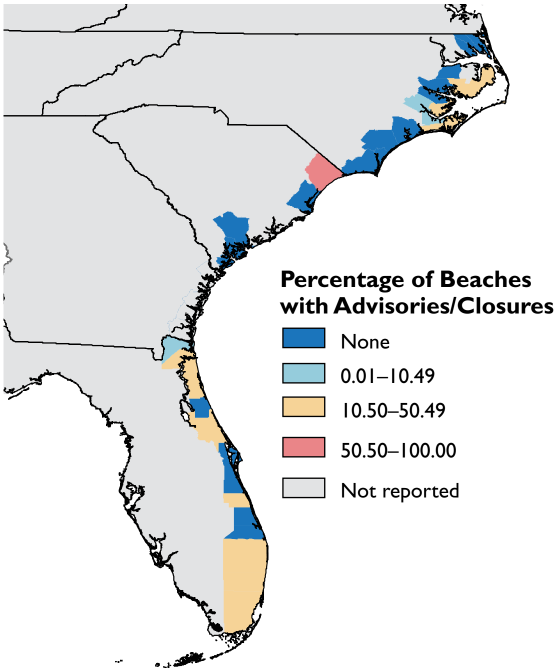


Figure 4-20. Percentage of monitored beaches with advisories or closures, by county, for the Southeast Coast region (U.S. EPA, 2006c).

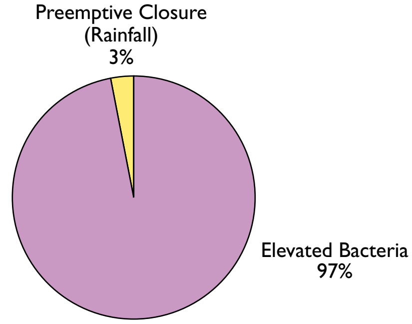


Figure 4-21. Reasons for beach advisories or closures in the Southeast Coast region (U.S. EPA, 2006c).

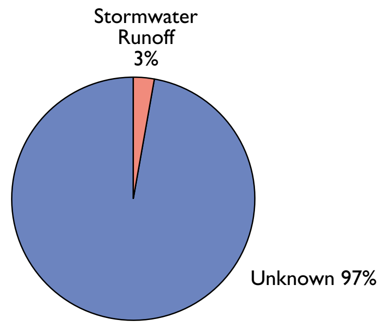


Figure 4-22. Sources of contamination resulting in beach advisories or closures in the Southeast Coast region (U.S. EPA, 2006c).

Leatherback sea turtles nest occasionally on the beach at Canaveral National Seashore. The leatherback is an endangered species of sea turtle and is one of the largest in the world. It can grow to be over 6 feet long and weigh over 1,000 pounds (courtesy of NPS).

Highlight

Responding to Sea-Level Rise

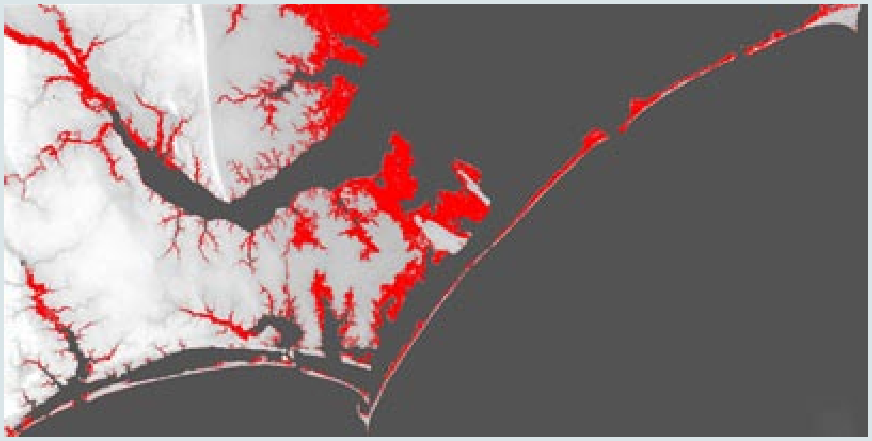
Sea level is expected to rise an average of 20 inches in the 21st century; about two to four times the rate observed over the 20th century (Houghton et al., 2001). A 20-inch rise in sea level will result in a substantial loss of coastal land and be associated with a host of other problems in coastal regions. These problems include the following:

- Higher and more frequent flooding of wetlands and low-lying coastal land
- Transformation of one ecosystem class to another
- Alteration of the function of the coastal area
- Increased flooding during severe storms
- Increased wave energy in nearshore areas
- Saltwater intrusion into coastal freshwater aquifers
- Breaching of coastal barrier islands
- Damage to coastal infrastructure
- Negative impacts to coastal economies
- Coastal erosion and coastal retreat, including dune and cliff erosion.

Sea-level rise is of special concern along the Southeast and Gulf coasts of the United States. The USGS evaluated vulnerability to sea-level rise by dividing the U.S. coastline into five categories based on geomorphology, coastal slope, relative sea-level change, shoreline erosion rate, tidal range, and mean wave height. The U.S. Southeast and Gulf coasts were determined to be the most vulnerable of the nation's coasts because of their low lying and gently sloping shorelines. In addition, the land in these regions is subsiding, while sea level is rising (Thieler and Hammar-Klos, 1999).

The prediction of shoreline retreat and land-loss rates is critical to the planning of future coastal zone management strategies, as well as to assessing biological impacts due to habitat changes and loss. To assist natural resource managers in mitigating the loss of coastal ecosystems resulting from the existing and predicted acceleration in the rate of sea-level rise, NOAA is developing digital coastal elevation maps with a vertical resolution of 8 inches, coastal flooding models that show the spatial extent of inundation for any projected rate of sea-level rise, and models of ecological response to inundation. NOAA has initiated the mapping and coastal flooding portions of this project for sections of the North Carolina coast. These sections include vulnerable areas and areas whose topography has been mapped by state agencies using light detection and ranging (LIDAR) technology, which is used to quantify coastal change with a rapidity of acquisition and very high data density. The digital elevation maps, hydrological models, and ecological models will ultimately be combined to produce forecasts of coastal change as a function of sea-level rise. One very important use of the forecasts for coastal planners is predicting the coastal response to specific proposals for coastal development.

In North Carolina, sea-level rise has occurred over the past several decades and has already had a major impact on the state's coastlines. Based on NOAA tide gauge measurements, the state's rate of relative sea-level rise ranges from 0.07 to 0.17 inches/year, with rates increasing from south to north (Zervas, 2004). As sea-level rises, the shoreline receeds and one ecosystem class may be transformed into another, significantly altering the function of coastal areas. Rates of shoreline recession vary dramatically along the shore and are a function of shoreline type, geometry, and composition; geographic location; size and shape of the associated coastal waterbody; coastal vegetation; water level; and storm frequency and intensity. In North Carolina, the coastal plain has low topographic slopes, and the majority of the coastal zone is within several feet of current sea level. As a result, North Carolina has lost almost 50 mi^2 of coastal area along the shoreline from 1975 to 2000 and as much as 60% of wetlands in the northeastern portion of the state (Riggs, 2001).



Areas in red along North Carolina Outer Banks, Bogue Sound, Pamlico Sound, and the Neuse River are projected to be inundated by a 40-inch rise in sea level (Zervas, 2004).

The coastal flooding model combined a hydrodynamic tide model of Pamlico, Albemarle, Core, and Bogue sounds and adjacent estuarine and coastal waters with the high-resolution, topographic/bathymetric digital elevation map based on the LIDAR topographic and bathymetric data (Zervas, 2004). The model forecasted the extent of inundation in Pamlico and Bogue sounds and the Neuse River as a function of a 40-inch sea-level rise (see map).

In 2005, NOAA initiated development of ecological models for the area of North Carolina covered by the coastal flooding model. A GIS-based database of shoreline variables (e.g., fetch, offshore bottom character, shoreline geometry, height and composition of sediment banks, fringing vegetation, boat wake, soil series, marsh zone width, land form type and location, elevation) will help forecast estuarine shore-zone modification driven by sea-level rise. One type of ecological model will predict the effects of present sea-level rise, increased storm surge intensity, bulkheads, and breakwaters on net primary and secondary production within five types of habitat: subtidal un-vegetated, SAV, intertidal flat, oyster reef, and marsh. Another model will predict the spatial distribution of biomass and sediment accretion on salt marsh platforms based on vegetation responses to changes in mean sea level.

The results of the ecological models will allow researchers to examine and evaluate the connections between different habitats and how these connections will be affected by sea-level rise in coastal areas. For example, forecasts of the effects of sea-level rise on forests and forested wetlands will allow researchers to link surface soil salinity to estuarine salinity using soil type maps and information about vegetation/land cover and elevation. Forecasts will be used to determine feedback and transition processes between marshes and forests and between marshes and subtidal environments, as well as evaluate which specific thresholds are needed to initiate state changes from one zone to another due to salinity, inundation regime, or episodic events. In addition, the ecological models will be integrated with landscape models to assess the impact of land use activities on natural and cultural resources and will be used to project the loss/alteration of habitat and resulting impact on biodiversity.

Summary

Based on data from the NCA, the overall condition of the coastal waters of the Southeast Coast region is rated fair. The NCA monitoring conducted by coastal states in 2001 and 2002 showed that DIN, DIP, and bottom-water dissolved oxygen concentrations; water clarity; sediment toxicity; sediment contamination; TOC levels; and benthic condition are rated good for Southeast Coast coastal waters. Indices of concern include the water quality index (54% of the coastal area is rated fair or poor, combined) and coastal habitat index (rated fair). Although no significant linear trends were observed in the available EMAP and NCA data (1994–2001), increasing population growth in this region could contribute to increased susceptibility for water quality degradation in the future.

NOAA's NMFS manages several fisheries in the Southeast U.S. Continental Shelf LME, including reef fish, sciaenids, menhaden, mackerel, and shrimp. Landings of reef fish have fluctuated, but are decreasing slightly over time. Fish in the *Sciaenidae* family generally support substantial harvests in the Southeast U.S. Continental Shelf LME, but one member, red drum, is currently classified as overfished. The fishing effort for menhaden in this LME has decreased since the 1950s, but NMFS considers this resource to be almost fully utilized. Neither the king nor Spanish mackerel stocks are considered overfished, but these stocks are at or near their long-term potential and optimum long-term yields, respectively. Although fishing pressure has increased, the Southeast U.S. Continental Shelf LME shrimp fishery has exhibited a 40-year stable trend in catch levels.

Contamination in Southeast Coast coastal waters has affected human uses of these waters. In 2003, 10 fish consumption advisories, most of which were issued for mercury contamination, were in effect for the Southeast Coast region. In addition, 12% of the region's monitored beaches were closed or under advisory for some period of time during 2003. Elevated bacteria levels in the region's coastal waters were primarily responsible for the beach closures and advisories.

Although the overall condition of Southeast Coast coastal waters is rated fair for the 2001–2002 time period, the promotion of a vigilant attitude and the continuation of environmental education would help to protect and preserve this resource, as well as to provide a measure of success for management actions.